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A Comparison of the marginal cost of commissioning officers through the U.S. Naval Academy, Naval Reserve Officers Training Corps, and Officer Candidate School

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NAVAL POSTGRADUATE SCHOOL

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THESIS

A COMPARISON OF THE MARGINAL COST OF COMMISSIONING OFFICERS THROUGH THE U.S. NAVAL ACADEMY, NAVAL RESERVE OFFICERS TRAINING CORPS, AND OFFICER CANDIDATE SCHOOL

by

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December, 1990

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by

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ABSTRACT

This thesis calculates and compares the marginal cost of graduating a naval officer from the United States Naval Academy (USNA), Naval Reserve Officers Training Corps (NROTC), and Officer Candidate School (OCS). After defining the variable and fixed cost functions for each commissioning source, the total cost, average cost, and marginal cost per graduate are calculated for fiscal year 1989 graduates. Compared to average cost, the marginal cost per Academy graduate is more in line with the marginal cost per graduate for NROTC, and OCS. The results support the conclusion that a majority of the Naval Academy's costs are fixed in the short-run and that savings realized by reducing the number of graduates would be overstated by using average cost. This thesis recommends using marginal cost to estimate savings from reductions in officer accessions in the short-run.

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I. INTRODUCTION

A. SOURCE OF THE ISSUE

In the 1990s, the military of the United States is likely to face significant changes in force structure and reductions of personnel. These reductions will be caused primarily by two major factors. First, while the early 1980s represented growth in the military, federal tax and expenditure policies also created a large budget deficit that the government is currently dedicated to reducing. Second, 1989 culminated with the overthrow of communism in eastern Europe, and the fall of the Berlin wall. This, coupled with improved relations between the United States and the Soviet Union, has provided the major impetus for a smaller, restructured American military force.

Despite the current military deployment to the Persian Gulf region, which may slow force reductions in the short-run, the perceived end of the cold war and the federal budget constraints will force the United States Navy to progress towards a smaller fleet within the next five years. This action will have a direct impact on officer and enlisted end-strength. Currently, top Congressional, Department of Defense, and Navy leaders are attempting to determine how officer end-strength will be reduced. One method is to reduce officer accessions. If this method is chosen, the

questions that must be answered include how much to reduce and from which sources.

The Navy commissions its officers through various programs. The three predominant sources, accounting for 54 percent of officer accessions in fiscal year 1989, are: U.S. Naval Academy (USNA), Naval Reserve Officers Training Corps (NROTC), and Officer Candidate School (OCS) [Ref. 1:p. 2].

When determining where and by how much to reduce accessions, several factors must be incorporated into the decision-making process. At a minimum, these include: the anticipated future steady state size of the Navy, the unique contributions of each commissioning source, costs of commissioning an officer by source, differences in officer productivity by source and warfare specialty, differences in officer retention, measures of commissioning source efficiency, effects on commissioning equal opportunity goals, effects on the number of technically-trained officers required, and the political implications involved with reducing commissions from each source.

In April 1990, Senator John Glenn, D-Ohio, chairman of the Senate Armed Services Committee's Subcommittee on Manpower and Personnel, raised important questions concerning the costs and value of service academy education, including the retention of academy graduates compared with officers from other sources. One specific concern is that service academies

are "the most expensive way to train officers, yet graduates do not remain in service significantly longer than other officers." His "bottom line question" is "whether they (the academies) are providing the kind of career-oriented officers needed to provide leadership." [Ref. 2:p. 8] Christopher Jehn, the Assistant Secretary of Defense, Force Management and Personnel, believes "each of the three commissioning sources is essential and serves a purpose that complements the other in terms of quality and readiness." [Ref. 2:p. 8] Barbara S. Pope, the Assistant Secretary of the Navy for Manpower and Reserve Affairs, states "as the size of the force gets smaller in the years ahead, we must maintain a balance between all sources of accessions." [Ref. 2:p. 8]

In a statement before Senator Glenn's subcommittee on 4 April 1990, Robert F. Hale, the Assistant Director of the National Security Division of the Congressional Budget Office, reported that it costs the government $153,000 for a Naval Academy graduate, $53,000 to train an officer in NROTC, and $20,000 to graduate an officer through OCS [Ref. 3:p. 6]. In Hale's study, his numbers are calculated using the concept of average cost. An alternative method would be to use the concept of marginal cost. Hale states:

> average costs would, however overestimate the effects of small changes in the numbers of students, particularly at the academies. The academies incur substantial costs to maintain their facilities and basic educational services ... which would not change if there were small changes in the numbers of students. Assessing the effects of small changes in the numbers of students would

require an estimate of marginal costs. [Ref. 3:p. 9]

When decisions must be made regarding incremental changes in the size of an operation, or program, marginal cost is the relevant variable.

B. OBJECTIVES

This thesis is an analysis of the marginal cost of commissioning Naval officers from the three major accession sources. This research will first identify exactly what costs are relevant to graduating an officer from each source. Second, cost data will be collected from each commissioning source. The cost data will be disaggregated into several different categories. A third task will be to use these categories to define three different components for each commissioning source: total cost, variable cost, and fixed cost. The marginal cost of graduating a Naval officer through each particular program will be derived from these components. The objective is to utilize the marginal cost results to demonstrate for manpower planners the change in cost for incremental changes in accessions.

C. SCOPE, LIMITATIONS, AND ASSUMPTIONS

This analysis does not address all 13 commissioning sources of Naval officers. Since the percentage of commissions from the sources other than USNA, NROTC, and OCS are small (the largest being nine percent from a single source in fiscal year 1989), excluding these sources, and all of

their costs, will not bias the results of this analysis. Table 1.1 presents accession percentages by source for fiscal year 1989.

TABLE 1.1 FY-1989 RELATIVE MIX OF NAVY OFFICER ACCESSIONS.

Source	Number/Percentage of Accessions
U.S. Naval Academy	958 (15%)
NROTC	1618 (25%)
ECP (Enlisted Comm. Program)	98 (1%)
OCS	972 (14%)
ROC/AVROC (Reserve Officer Candidate Program/Aviation ROC)	55 (1%)
AOC/NFOC (Aviation Officer Candidate Program/ Naval Flight Officer Candidate Program)	568 (9%)
NAVCAD (Naval Aviation Officer Cadet)	106 (2%)
Merchant Marine Recall	33 (.5%)
From enlisted	583 (9%)
The following sources are used primarily for medical accessions:	
Recall	235 (3%)
Interservice Transfer	30 (.5%)
Direct Procurement	710 (11%)
Student Option	588 (9%)
Total	6554 (100%)

Source: Statement of Mrs. Barbara S. Pope, Assistant Secretary of Navy (Manpower and Reserve Affairs), before the Manpower and Personnel Subcommittee of the Senate Armed Services Committee, 4 April 1990.

Also, it is not the intention of this study to determine the optimal or preferred mix of officer accessions from the three major sources. This would require an intensive analysis of all of the factors previously discussed, an analysis of all the pertinent constraints, and the specific goals of

Congressional and Defense leaders. Linear programming models, such as the one used by Kleinman and Goudreau, discussed in the next chapter, could be used to determine the optimal accession mix, but such an effort is beyond the scope of this thesis.

The analysis in this thesis is limited to the specific economic costs of producing officers. It does not analyze the non-economic costs of producing commissioned officers from a particular source. These would include the impact on the number of nuclear surface/submarine commissions, the possible reduction in opportunity for enlisted personnel to become officers, the effect on the Navy's minority accession targets, the possible effect of reduced visibility on college campuses (if NROTC units were closed), and the political implications (Congress, constituents, lobby groups) of reducing a particular source. An accurate, well developed study of these particular areas, though important, is beyond the scope of this thesis.

This analysis assumes that no commissioning source will be completely eliminated. While it is clear that options such as closing the Naval Academy and NROTC units would save the Department of Defense considerable money, the political ramifications of such major decisions are beyond this analysis.

D. ORGANIZATION OF THE STUDY

Chapter two provides a review of the relevant literature and builds the theoretical framework for the marginal cost analysis. Chapter three includes a discussion of the data, and a discussion of the methodology used to generate the results. Chapter four provides the results of the analysis, and the marginal cost estimates associated with changes in the number of graduates from each commissioning source. Chapter five draws conclusions and recommendations based on these results, and recommends areas of further research.

II. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

A. BACKGROUND

Each commissioning program has evolved to fill a different need. Each also trains officers in quite a different way, yet the officers must be able to perform in the same arena and accomplish the same missions. Before 1845, new Naval officers received most of their training at sea in the fleet. An increasing requirement for more qualified junior officers and specifically, engineers, lead to the establishment of the Naval Academy in 1845.

Through World War I, most Naval officers received their commissions from the Naval Academy. Congress authorized the Navy to establish the NROTC college program in 1925 to provide educated reserve officers to the fleet. During World War II, the Navy concentrated on training officers instead of providing an education. However, by the end of the war, Navy leadership determined that more technically-educated officers would be needed. Rear Admiral James Holloway was appointed to chair a board to recommend to the Navy an encompassing "method of educating Naval officers." The Holloway plan, as it was called, recommended a plan for acquiring "regular" officers from 52 civilian colleges and universities. [Ref. 4]

In 1946, Congress authorized the NROTC scholarship program. This program, in conjunction with the Naval Academy,

"provided the flexibility necessary to meet the inevitable fluctuations in the number of officers required and the capability of obtaining a sufficient number of civilian-educated naval officers." [Ref. 4:p. 3] The NROTC program has expanded to its current size of 66 colleges and universities.

At the start of the Korean War, the Navy established the Officer Candidate School program to supplement the other programs. With this being the Navy's first "post-college procurement program," it provided a large bank of college-educated people that required a relatively short training period to become officers. [Ref. 4:p. 3]

The Military Manpower Training Report, prepared every fiscal year by the Office of the Assistant Secretary of Defense (Force Management and Personnel), discusses officer acquisition, and training programs. It states that the "mix of officer acquisition programs used must recognize the differing characteristics of each source." [Ref. 5:p. IV-4] The Naval Academy represents a program with a long lead-time that supplies constant input levels to the active duty officer corps. It provides "high academic quality with comprehensive military indoctrination." [Ref. 5:p. IV-4] NROTC, likewise, provides consistent input levels, with a majority of midshipmen joining the reserve components of the service. The NROTC scholarship program offers a four-year scholarship, provides student pay and allowances over the length of the scholarship, and includes three summer training cruises in the

fleet. The NROTC college program only provides student pay and allowances over the last two years of college, and has only one summer cruise. Barbara Pope, in a statement before the Manpower and Personnel Subcommittee of the Senate Armed Services Committee, emphasized these two programs. She stated that:

> although the education of the individual is a major benefit of the USNA and NROTC programs, this is not what makes them unique. Instead, it is the development of a cadre professional military officer force deeply imbued with the highest traditions and heritage of the Naval service, dedicated to a career of service to their country. [Ref. 1:p. 1]

OCS, on the other hand, is a 16-week, flexible commissioning source that can quickly respond to increases or decreases in the quantity of officers demanded.

Previous research on the costs of commissioning sources is limited. Robert Hale's testimony before the Senate Manpower subcommittee was based on research conducted at the Congressional Budget Office. This testimony discussed the major differences in costs among commissioning sources. An NROTC graduate costs approximately one-quarter to one-third as much as an academy graduate. Some reasons for this include: many NROTC students attend schools that cost less to operate than USNA, and USNA incurs costs that other colleges do not. These costs include: pay for students, mandatory summer training programs, clothing, room and board, complete military instruction, and an intensive engineering program. Though the NROTC program incurs some of these costs -- student pay and

allowances, military instruction, and summer cruises -- USNA devotes more assets to these functions. OCS costs are the smallest of the three, approximately six to 13 percent as much as a USNA graduate and one-quarter to one-third as much as an NROTC scholarship. Two major reasons for this are the relatively short duration of the OCS program, and the fact that OCS does not provide a college education. [Ref. 3:pp. 7-8]

In a 1977 study, Samuel Kleinman and Karen Goudreau constructed a linear programming model to solve for the optimal number of accessions from each source. They used fiscal 1976 costs from nine accession points. In their model, they found that six of the nine commissioning programs consistently entered their optimal mix of accession programs. Those six were USNA, NROTC, OCS, Aviation OCS, Naval Flight OCS, and the Naval Enlisted Scientific Education Program.[1] The objective of their model was to "minimize officer costs subject to the constraint that for each designation, the required number of officers at each rank is met within limits to program adjustments." [Ref. 4:p. 6] They state that their research was the first comprehensive study of officer recruitment programs. It appears that none have been conducted since.

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[1]The Naval Enlisted Scientific Education Program is no longer in existence.

Kleinman and Goudreau's estimations of precommissioning training costs were computed separately for each commissioning source because they were unable to perfectly match the individual cost elements of the different sources. They discounted costs back to what they called the "decision point," defined as four years prior to commissioning. The data they received from the Navy was undiscounted. Kleinman and Goudreau believed that the Navy's policy of "growing their own" force required using a discount rate that reflects the "opportunity cost of foregone investments." They used a discount rate of ten percent. [Ref. 4:p. 10] For USNA and NROTC, programs with expenditures throughout the year, costs were discounted from the middle of the year. For OCS, they assumed that costs were expended just prior to commissioning. By using discounted and undiscounted data sets, they confirmed through their analysis that for discount rates up to ten percent, accession levels obtained from their linear program "are unchanged," and "insensitive" to discounting [Ref. 4:p. 14].

Kleinman and Goudreau divided costs at USNA into 39 categories under the major groups of instructional activities, student-related activities, instructional support, and Marine instructor support. Costs were measured for the fiscal year 1976 class by taking the average cost per graduate. The NROTC costs were divided into the following categories: direct support, unit costs, command costs, and miscellaneous costs.

In 1977, OCS was a 19-week program and the costs were based on the man-months of training. Costs associated with OCS were divided into military pay, operations and maintenance, major projects, hospital, housing, equipment maintenance, staff permanent change of station, student travel, and student pay and allowances.

For each of the commissioning sources, the cost of commissioning one officer through the program was listed. This was an average, not a marginal, cost. The fiscal year 1976 average cost of commissioning an officer through USNA was $83,428, through NROTC (scholarship) $27,285, NROTC (non-scholarship) $22,093, and through OCS, $6,343. Based on their study, Kleinman and Goudreau recommended that the minimum service requirement be extended from three to four years for the NROTC College Program. Though this did not allow the NROTC College Program to be included in the optimal mix of accession sources, they did compute that this recommendation would save the Navy $1.2 to $1.6 million if the supply of those officers decreased from 125 to 100.

A potential weakness in this study is the fact that the retention and promotion rates used were based on historical data. If one assumes that it is possible to accurately determine these rates in this fashion, these rates would only be realistic if the factors influencing officers to remain in the Navy, and the selection criteria used by the promotion selection boards do not change. This is unlikely. The

quality of officers being accepted is also not included in the analysis. This quality may be affected by social and economic trends external to the Navy. The exclusion of these factors also may have influenced the outcome of the analysis.

Also in 1977, an indepth study was conducted by Barrow, at the Center for Naval Analyses, on the costs of 1976 NROTC graduates by school. While the data are outdated, the procedure used is sound. The costs were accumulated by cohort as the costs were incurred. For example, if the total amount spent in scholarships in fiscal year 1989 were $2,000,000 and the freshmen scholarship students comprised 20 percent of the total scholarship students, then 20 percent of $2,000,000 would be charged to the freshmen class. The same procedure is used as they became sophomores, juniors and seniors. The individual amounts are then summed to represent that particular cohort's total cost. [Ref. 6:p. 2]

The study grouped costs into three general headings: direct student costs, unit costs, and headquarters costs. The CNA study found that unit costs were related to the number of NROTC units, but not student enrollment within the unit. Therefore, if the number of students were to increase or decrease by a small amount, there would be no change in overall commissioning costs. He found headquarters costs to be even less "sensitive" to the number of students or the number of units. Therefore, in a marginal cost study, these costs would be treated as fixed costs. [Ref. 6:p. 2]

CNA did not include the cost of student attrition in its analysis because "student flow into and between the Scholarship and College programs made it virtually impossible to estimate." [Ref. 6:p. 3] However, CNA devised a formula that it used as a proxy for the scholarship attrition rate. CNA's results are the fiscal 1976 cost-per-commissionee at each of the 58 NROTC units then in existence. CNA's results are illustrated in Table 2.1 as a percentage of the average program-wide costs listed in the table.

On 11 June 1990, Deputy Secretary of Defense Atwood requested, at the urging of Congress, that the Department of Defense prepare a report that addresses three specific areas concerning future commissioning programs: "reducing costs; ensuring a proper mix of backgrounds, skills, and experience in the officer corps; and maintaining a sound force structure, with no hollowing of the force." [Ref. 7:p. 1]

This report recommended four principle actions. The first recommendation was to reduce the size of the entering classes at the Naval Academy to 1,100 midshipmen, graduating between 750 and 800 per year. This will result in a reduction of approximately 200 to 250 commissions per year, or roughly 25 to 33 percent. Table 2.2 shows the number of graduates from the Naval Academy each year since 1946. The mean number of graduates since 1946 has been 891.

The second recommendation was to modify the faculty mix at the Military and Air Force Academies by increasing the number

TABLE 2.1 PERCENTAGE OF 1976 AVERAGE COST (ADJUSTED FOR INFLATION) PER NROTC COMMISSIONEE BY UNIT.

Total average cost per graduate unadjusted for inflation: $25,174

Total average cost per graduate adjusted for inflation: $28,732

NROTC unit	Percentage	NROTC unit	Percentage
Auburn	63	Northwestern	234
Berkeley	132	Notre Dame	129
Citadel	58	Ohio State	61
Colorado	107	Oklahoma	129
Cornell	140	Oregon State	76
Duke	138	Pennsylvania	92
Florida	186	Penn State	85
Florida A&M	117	Prairie View	81
Georgia Tech	94	Purdue	109
Holy Cross	131	Rensselaer	143
Idaho	85	Rice	182
Illinois	102	Rochester	121
IIT	70	Savannah State	118
Iowa State	91	South Carolina	77
Jacksonville	110	Southern A&M	82
Kansas	142	Suny Maritime	111
Louisville	99	Texas	104
Maine Maritime	41	Texas A&M	84
Marquette	265	Tulane	119
MIT	129	UCLA	131
Miami	80	USC	127
Michigan	104	Utah	102
Minnesota	72	Vanderbilt	97
Mississippi	78	Villanova	92
Missouri	57	Virginia	77
Nebraska	157	VMI (1)	--
New Mexico	82	Washington	63
North Carolina	103	West Florida	307
North Carolina Central	377	Wisconsin	104

Source: Costs of 1976 NROTC Commissionees By School, A CNA Study

Notes:

(1) VMI is a new unit that did not commission any officers in 1976.

of civilian professors, and to consolidate the different service preparatory schools into one "joint" school. Third, during the period 1992 to 1996, it was recommended that ROTC commissions, across all services, be reduced by 19 percent. Fourth, the report recommended maintaining OCS commissioning output at current levels, and increasing the program as necessary to meet any unexpected shortages. [Ref. 7:p. cover sheet] To provide insight into the relative mix from all accessions sources across the services, Table 2.3 provides the trend for the last 10 years.

The DOD report states that current (1990) projections for new commissions in 1997 will be 2,327 below the 1990 level, or a decrease of 9.2 percent. However, the report also states that these accession projections may be "inconsistent" with the actual end-strength programmed for fiscal year 1997. The Department of Defense expects that the future projections of officer end-strength will decrease even more as world events evolve. The report's recommendations, therefore, are based on officer recruitment of 2,277 below the current projections for 1995, the projected date of completion of the force drawdown. [Ref. 7:p. 6]

DOD anticipates savings through reduced officer accessions in two areas. First, midshipmen pay and allowances, and the costs associated with support and scholarships are expected to decline. Savings "will be realized by reducing the number of students enrolled and by shifting the mix towards the low-cost

TABLE 2.2 SIZE OF NAVAL ACADEMY GRADUATING CLASSES.

Class	Size	Class	Size	Class	Size
1946	1046	1961	786	1976	831
1947	820	1962	789	1977	967
1948	910	1963	886	1978	986
1949	790	1964	925	1979	932
1950	691	1965	801	1980	946
1951	725	1966	868	1981	966
1952	783	1967	889	1982	1030
1953	925	1968	836	1983	1077
1954	855	1969	879	1984	1004
1955	742	1970	838	1985	1044
1956	681	1971	874	1986	1029
1957	848	1972	905	1987	1036
1958	899	1973	891	1988	1060
1959	796	1974	919	1989	1082
1960	798	1975	811		

Source: Memorandum for Deputy Secretary of Defense dated 10 August 1990, "Review of Programs for Obtaining Officers for the Armed Forces."

TABLE 2.3 PERCENTAGE OF OFFICERS COMMISSIONED BY TRAINING PROGRAM.

Calendar Year	Academies	ROTC	OCS/OTS
1980	9	25	28
1981	9	26	25
1982	9	30	20
1983	9	31	23
1984	11	36	19
1985	10	34	24
1986	11	31	23
1987	12	34	18
1988	13	38	13
1989	12	37	12

Source: Data supplied by Department of Defense
Table provided by Robert F. Hale's, Assistant Director National Security Division, Congressional Budget Office, testimony before the Subcommittee on Manpower and Personnel Committee on Armed Services, United States Senate, 4 April 1990.

Note: Percentages do not add to 100 because numbers exclude direct appointments (lawyers, doctors, etc.), warrant officers, and others. Also, CBO percentages reported here are different than the percentages obtained from SECNAV and shown in Table 1.

sources such as OCS, and NROTC non-scholarship." [Ref. 7:pp. 6-7] Second, indirect costs will be less (e.g., faculty and staff, fixed overhead, and other institutional support costs). The largest savings are derived from reduced enrollments. Additional savings stem from the increased civilian-to-military instructor ratio, and the consolidation of the academy preparatory schools into one location. Total savings are almost $700 million across the services, or ten percent of total officer acquisition costs in the POM (Program Objective Memoranda) for fiscal years 1992 through 1996. [Ref. 7:pp. 6-7]

The DOD report prepared its savings estimates by calculating the marginal cost of graduating an officer through each of the service academies. Using the Army Manpower Cost System, in fiscal year 1991 dollars, the marginal cost of graduating an Army officer through the Military Academy is $101,000. The marginal cost of graduating a Naval officer through the Naval Academy is "only about $35,000 per graduate." [Ref. 7:p. 2 of Tab D] This report states that most of the difference between the U.S. Military Academy and the U.S. Naval Academy were due to differences in the military personnel account, and that the Navy's facility training costs were treated as fixed, therefore eliminated [Ref. 7:p. 3 of Tab D]. This is a questionable assumption, as the facility training costs are not all fixed. Reducing student enrollment while maintaining current faculty-to-student ratios would also

entail a reduction in faculty. If this option was exercised, then some of the faculty expenses would also be variable.

The expected NROTC savings were based on the Congressional Budget Office average cost study completed in June of 1990. This formed the basis of Hale's testimony before Congress, which was discussed earlier [Ref. 7:p. 4 of Tab D]. This procedure appears to be inconsistent with the methodology of a marginal cost analysis used by DOD to determine academy costs. The DOD study's results are shown in Table 2.4.

TABLE 2.4 SUMMARY OF NAVY OFFICER ACCESSIONS SAVINGS IN FY-91 DOLLARS ($1,000s).

	FY92	FY93	FY94	FY95	FY96	TOTAL
reduced USNA graduates	2,727	5,980	8,589	11,971	11,971	41,237
restructure NROTC	4,819	9,638	14,457	19,277	19,277	67,468

Source: Memorandum for Deputy Secretary of Defense dated 10 August 1990, "Review of Programs for Obtaining Officers for the Armed Forces."

B. THEORETICAL FRAMEWORK

The major contribution of this thesis is to provide a different perspective on accession point costs. Specifically, the concept of marginal cost is compared to average cost. Before an understanding of the difference between these two

concepts can be achieved, underlying definitions must be developed. If one thinks of commissioning officers as a production process, and the costs of commissioning them as input costs, then the established theory of cost and production in microeconomics can be applied to the commissioning process.

Any production process can generally be divided into long-run and short-run periods of time. In the long-run, all inputs into the process, such as capital and labor, are considered variable and change as the quantity of output changes. In the long-run, the costs associated with changes in all inputs are also variable in nature, and thus depend on the output level. The short-run is a period of time during which certain inputs, and their associated costs, cannot be physically changed regardless of the amount of output produced. For example, the physical plant associated with an operation is usually fixed in size over most ranges of output. Costs associated with these fixed inputs are considered fixed costs because they can only be altered in the long-run.

It is appropriate to define the short-run and long-run cost components because this will accurately illustrate to Defense leaders, who must make force reduction decisions, what each decision will save in terms of dollars. In the short-run, due to the short duration and flexibility of the program, it is believed that OCS will be the source of adjustments in officer accessions. This statement is confirmed in a letter

from Vice Admiral Boorda, Deputy Chief of Naval Operations (Manpower, Personnel and Training), to the Superintendent of the Naval Academy concerning fiscal year 1990 officer accessions [Ref. 8]. All future beginning classes at the Naval Academy and NROTC colleges and universities will be considered for reductions.

In using economic decision aids, one must consider the relevant costs of production. These are defined as "any cost that actually affects a given decision and therefore should be considered in the decision process." Sunk costs are those "that are not affected by a specific decision and therefore irrelevant to that decision." The concepts of "increment," "relevant," and "variable" costs are all closely related to the concept of "marginality." [Ref. 9]

In general, economic costs are defined in terms of opportunity costs. Pappas and Hirschey state that opportunity cost is "the value of a resource in its best alternative use." [Ref. 9] This important economic concept is crucial to the development of production decision-making, because if production costs are greater than opportunity costs, an organization or firm would stop producing. Opportunity costs will be determined by Navy policy.

Short-run total cost is the sum of the fixed costs and variable costs. In the short-run, the only way output can be changed is to alter the variable inputs. Long-run total cost is the sum of all relevant costs. Average total cost (average

cost) is the total of all fixed and variable costs divided by the output (total costs of a commissioning source divided by the number of graduates for a given year equals the cost per graduate). Marginal cost is "the change in total cost per unit change in output." [Ref. 10] The unit of output in this case would be a commissioned officer. The marginal cost would be the increase (or decrease) in total cost that occurs when one more (less) student graduates. Marginal cost takes into account that fixed costs cannot be altered in the short-run. The fixed costs include, for example, operating facilities which would still exist if there was a reduction by one officer. Marginal cost is derived by taking the derivative of the total cost equation. The total cost equation takes on the form of:

$$TC = FC + VC(Q)$$

where TC is the total cost of a commissioning source, FC is the total fixed costs, VC is the total variable costs, and Q is the number of graduates for a given year. The derivative of a constant (FC) with respect to Q is zero. The derivative of the above equation equals the derivative of VC(Q) with respect to Q:

$$\frac{d(TC)}{dQ} = \frac{d(FC)}{dQ} + \frac{d(VC(Q))}{dQ}$$

which simplifies to:

$$\frac{d(TC)}{dQ} = \frac{d(VC(Q))}{dQ} = marginal cost$$

Therefore, fixed costs do not play a roll in marginal cost functions in the short-run. In the long-run, however, it is important to remember that all inputs and, therefore, all costs are variable.

The following example will illustrate the theoretical framework. Hale's study states that the average cost of a USNA graduate is $153,000. By definition, the $153,000 includes some fixed costs. The USNA Comptroller office reported to the author of this thesis that the Academy is designed for approximately 3,700 midshipmen at a given time, and the usual enrollment can reach as high as 4,500 midshipmen without the need for additional facilities. Thus, fixed facility costs for Bancroft Hall, the Midshipmen dormitory, remain the same with an additional 800 students present. Therefore, if accessions were cut by 800 for a given year, these fixed facility costs would remain the same and only variable costs and some minor fixed costs would change. [Ref. 11] Average cost per graduate, in this case, would overstate the relevant marginal cost figure because fixed facility costs have not changed.

C. PROBABILISTIC BUDGETS

While all of the cost calculations in this thesis are based on previous years' data, using these precise results for

future years may be misleading. Fixed and variable cost components often vary by relatively small dollar amounts from year to year. The construction of cost estimates that contain expected values, and a probability interval, or confidence interval, provides a more accurate representation of the range within which the true cost figure is likely to be found.

In 1970, William L. Ferrara and Jack C. Hayya published an article in the journal, Management Accounting, entitled "Toward Probabilistic Profit Budgets," in which they developed the idea of creating a confidence interval for each of the elements of a budget. They first presented the idea of determining an optimistic, pessimistic, and most likely value of each element. From these values, using either probability-tree analysis or PERT (Program Evaluation and Review Technique) formulas, the mean and standard deviation of an element could be determined. From these statistically descriptive characteristics, a probability interval can be determined using statistical probability tables.

Ferrara and Hayya conclude that the "probability interval ... tells us that a stated percentage of the distribution of a budget item falls within a given range. Thus the probability interval serves as a measure of variability for the budget item." [Ref. 12]

Ideally, confidence intervals would be calculated for the estimates of marginal cost presented in this thesis. However, one would need several years of data to construct these

intervals. Since data was only collected for one graduating class, it is impossible to calculate confidence intervals in this case. However, as long as this data are representative of typical commissioning source operations, the values of marginal cost that are obtained should be within the intervals for larger samples.

D. ECONOMIES OF SCALE

Pappas and Hirschey define economies of scale as "production or marketing advantages that lead to a decline in long-run average costs." [Ref. 9:p. 257] Maurice and Smithson further elaborate on this concept by stating that with increasing returns to scale, there is a decline in the average cost curve, and with decreasing returns to scale, there is an increase in the average cost curve. They illustrate the concept with the following example. If an organization doubled its output, and the increase in the input level is less than double, than average cost will fall. However, if an organization is operating in a range of decreasing returns to scale, also known as diseconomies of scale, doubling output will require more than two times as much input, and, average cost will rise. They state that as "the size of plant and the scale of operation become larger, ceratin economies of scale are usually realized." [Ref. 10:pp. 289-290]

No previous studies have been identified that conduct research on the possibilities of economies of scale at USNA, NROTC, or OCS. One may argue that by reducing the number of

midshipmen at the Naval Academy, though marginal cost may be lower than average cost, the average cost will rise because the number of graduates per year will decrease, making the denominator of the average cost calculation smaller. However, because of economies of scale, an increase in average cost may not always occur. Mathematically, long run average cost is defined as:

$$LRATC = \frac{TC}{Q} = \frac{VC(Q)}{Q}$$

where TC is total cost, VC is variable cost, and Q is the number of graduates.

Typically, long-run total costs (hence long-run variable costs) increase as production increases. If total cost increases faster than production, long-run average total costs increase and there are decreasing returns to scale. On the other hand, if economies of scale exist, it may be possible to increase production, the number of graduates, and reduce long-run average total costs. If the long-run total cost grows at a slower rate than output, then the long-run average cost of a graduate would decrease. There have been at least four studies conducted that have shown some degree of economies of scale in private and public education systems. Most recently, Scott J. Callan and Rexford E. Santerre conducted a study using the 165 school districts in Connecticut. Their results suggest that a "ten percent increase in primary and secondary

school quality-adjusted enrollments would individually result in a .9 percent and 1.1 percent increase in variable costs, all else equal." [Ref. 13] This result shows that partial economies of scale exist in Connecticut, and that "educational cost savings might be achieved through further consolidation of primary and secondary school districts." [Ref. 13]

Bee and Dolton, in their study on costs and economies of scale in the United Kingdom's private schools, use linear regression analysis to show that "there may be considerable fixed costs in school operation and that there are considerable economies of scale in the operation of fairly large schools due to continually declining cost curves." Their two main findings are that school size is negatively correlated with average cost, which suggests that economies of scale are present, and that "no obvious relationship between performance and average cost is revealed." [Ref. 14]

Kumar, in his analysis of economies of scale in school operations in Canada, strongly believes that the "importance of economies of scale studies of school costs can hardly be overemphasized in a period of generally contracting school systems." Using Watt's 1980 study of economies of scale from the private sector, Kumar develops a general methodology for investigating economies of scale. He uses linear regression techniques to estimate average cost curves that fit the form of $AC = f(S, X_1, X_2, \ldots X_n; Q, P_1, P_2, \ldots P_n)$ where S is the size of the educational system, $X_1, X_2, \ldots X_n$ are exogenous

factors that may account for differences among units under study, Q is the quality of education output, and $p_1, p_2, \ldots p_n$ are the prices of educational inputs. He then states that there are two major problems with estimating this equation: the selection of the appropriate functional form, and measuring the quality of education. Kumar states that the commonly accepted procedure is to select a quadratic function of S, and create a variable that accounts for differences in the quality of education. This leads to the following form:

$$AC=\alpha_0+\alpha_1 S+\alpha_2 S^2+\sum \beta_i X_i+\sum \gamma_j Q_j$$

The first summation is over all of the different exogenous factors that may account for differences among the units under study. The second summation is over all of the differences in the quality of education. Kumar's results show that in "1975, 1976, and 1977, the board could have saved respectively $74, $99, and $168 per student by increasing average school size by 100 students." [Ref. 15]

Because of the magnitude of the fixed inputs at the Naval Academy, there is a strong possibility that economies of scale exist. This would play a significant role in estimating savings obtained by increasing or decreasing student enrollment. Since an analysis of this magnitude is beyond the scope of this thesis, it is strongly recommended that further research be conducted on economies of scale.

III. DATA AND METHODOLOGY

The purpose of this chapter is to describe the data, and discuss the specific methodology that is used to determine the marginal cost per graduate for each commissioning source.

A. DATA

There are three primary data sources for this thesis: the Naval Academy Comptroller's office; the Chief of Naval Education and Training, code N-11; and the Chief of Naval Education and Training Program Management Support Activity (NETPMSA).

1. U.S. Naval Academy

Naval Academy expenditures are divided into three categories: Operations and Maintenance, Navy Labor (O&M,N); Operations and Maintenance, Navy Material (O&M,N); and Military Pay Navy (MPN). There are 38 standard cost functions that are used by the U.S. Military Academy, the U.S. Air Force Academy, and the U.S. Naval Academy. Each of these cost functions are further divided into subfunctions, each receiving funding from O&M,N labor, O&M,N material, and MPN. As an example, the fiscal year 1989 cost figures for each function are shown in Table 3.1. Appendix A includes a table of fiscal year 1989 cost figures by subfunctions, and tables of fiscal years 1986 through 1988 cost figures by function. Past fiscal year data will be necessary to compute the

TABLE 3.1 FY-1989 NAVAL ACADEMY COSTS (DOLLARS) BY FUNCTION.

Functions		Total Cost
1. Academic Dean		$ 40,897,960
2. Audio/Visual Support		858,871
3. Academic Computer Center		3,247,524
4. Faculty Training	(1)	
5. Military Training		22,082,446
6. Physical Education		3,697,935
7. Library		2,833,757
TOTAL INSTRUCTIONAL ACTIVITIES		73,618,493
8. Cadet/Midshipmen Mess		6,514,775
9. Student Services		1,602,471
10. Registrar		2,787,200
11. Student Pay and Allowances		35,094,969
TOTAL STUDENT RELATED ACTIVITY		45,999,415
12. Medical		4,503,765
13. Band		1,131,628
14. Printing Plant	(2)	
15. Admin Data Processing	(3)	
16. Civilian Personnel		1,160,583
17. Personnel Administration		2,154,041
18. Special Services		277,959
19. Other Personnel Services		1,077,716
20. Utility Services		7,522,468
21. Custodial Services		2,989,576
22. Fire Protection		1,412,555
23. Maintenance and Engineering		22,808,777
24. Communications		1,674,747
25. Trans. Ops, and Equip. Maintenance		1,765,978
26. Commissary and Food Services		757,910
27. Supply and Services Operations		2,601,987
28. Logistics Activities	(4)	
29. Comptroller		1,875,105
30. Security		3,572,629
31. Prep School		5,909,839
32. PCS Travel	(5)	
33. Military Support Unit		243,258
34. Museum		197,820
35. PAO	(6)	1,044,031
36. Command and Staff		1,206,711

TABLE 3.1 FY-1989 NAVAL ACADEMY COSTS (DOLLARS) BY FUNCTION CONTINUED.

Functions		Total Cost
37. All Other Functions	(7)	
38. Stewart Army Annex	(8)	
Total Institutional Support		65,889,083
TOTAL COST FOR FY-1989 IS:		**$ 185,506,991**

Source: USNA Comptroller's Office

Notes:
(1) Other service academies fund their military faculty to get a Master's degree before they become instructors. Naval officers come to USNA with their degree, funded by other means.

(2) Other service academies have their own printing plant. USNA acquires its printing services through the Navy Printing Publication Office (NPPSO). Funding for these services comes from the departmental O&M,N material category.

(3) These costs are included in function 3.

(4) This category is considered a Supply activity for the Navy. This is used for Army and Air Force.

(5) Omitted for USNA. These permanent change of station (PCS) costs used to be retrieved from the Personnel Support Detachment (PSD) for incoming and outgoing military personnel. However, the Comptroller department found that this was a double count because the Composite Rate Table from NAVCOMPNOTE 7041 shows that PCS costs are paid through military pay and therefore, spread throughout the MPN category of the 38 functions.

(6) Public Affairs Office

(7) This function is used by the other service academies only.

(8) This function is used by the U.S. Military Academy only.

composite fiscal year 1989 marginal cost per graduate. This data has been confirmed by the Government Accounting Office via audits performed during the summer of 1990. Thus, the data from the Naval Academy are considered reliable and used as the basis for computing marginal cost.

2. Naval Reserve Officers Training Corps

NROTC funding is divided into the following categories: Military Pay, Navy (MPN); Reserve Personnel, Navy (RPN); and Operations and Maintenance, Navy (O&M,N). The MPN account funds the Navy staffing (Professors of Naval Science) at the NROTC units. The RPN account funds uniforms, midshipmen travel for summer training cruises, naval science textbooks, and student pay/subsistence of $100 per month for up to ten months per year. The O&M,N account funds tuition costs and program/unit costs. The latter consists of special procurement costs, civilian staff salaries, travel for staff members, and telephone expenses. Tuition is paid only for the full scholarship program, and varies per university. NROTC pays both in-state and out-of-state tuition rates, depending on the particular student's home of record. Besides tuition, the four-year scholarship program provides $100 per month subsistence pay, all books, and uniforms. The college program does not cover tuition, but does cover naval science books, certain lab fees, uniforms, and the $100 subsistence payment for the last two years. The Chief of Naval Education and Training does not segregate costs into scholarship and non-

scholarship. Therefore, the cost figures provided in Table 3.2 are combined. The Navy does not pay for the use of university buildings or utilities, which constitute much of the fixed, overhead costs at the Naval Academy. The campuses treat the NROTC unit as a division of the school and provide faculty members for instruction in non-ROTC courses, secretarial support, and computer support. Table 3.3 provides the fiscal year 1989 accessions from each NROTC unit.

TABLE 3.2 FY-1989 NROTC PROGRAM COSTS ($ 000s).

MPN	
- Navy staffing of NROTC units	$ 26,950
RPN	
- Midshipmen travel	
- uniforms	
- subsistence	
- naval science textbooks	17,158
O&M,N	
- tuition costs	46,337
- program/unit operations	7,082
TOTAL	$ 97,527

Source: Chief of Naval Education and Training (Code N-11)

3. Officer Candidate School

OCS funding is divided into three categories: Operations and Maintenance, Navy (O&M,N); Military Pay, Navy

(MPN); and Student Pay and Allowances. Table 3.4 provides a breakdown of the cost categories within the three funding

TABLE 3.3 FY-1989 NROTC PRODUCTION BY UNIT.

NROTC UNIT	TOTAL ACCESSIONS
University of Arizona	35
Auburn University	63
Boston University	33
University of California (Berkeley)	40
University of California (Los Angeles)	23
Carnegie Mellon University	0
The Citadel	33
University of Colorado	39
Cornell University	43
Duke University	30
University of Florida	28
Florida A&M University	20
George Washington University	39
Georgia Institute of Technology	23
Hampton Roads Consortium (1)	40
The College of The Holy Cross	30
University of Idaho	25
Illinois Institute of Technology	19
University of Illinois	28
Iowa State University	31
Jacksonville University	21
University of Kansas	17
Maine Maritime Academy	20
Marquette University	34
Massachusetts Institute of Technology	36
Memphis State University	11
Miami University	24
University of Michigan	24
University of Minnesota	20
University of Mississippi	5
University of Missouri	29
Morehouse College	17
University of Nebraska	17
University of New Mexico	13
University of North Carolina	47
Northwestern University	44
Norwich University	33
University of Notre Dame	55
Ohio State University	42
University of Oklahoma	29

TABLE 3.3 FY-1989 NROTC PRODUCTION BY UNIT CONTINUED.

NROTC UNIT	TOTAL ACCESSIONS
Oregon State University	32
University of Pennsylvania	32
Pennsylvania State University	56
Prairie View A&M University	6
Purdue University	29
Rensselaer Polytechnic Institute	47
Rice University	8
University of Rochester	57
San Diego Consortium (2)	39
Savannah State College	5
University of South Carolina	23
University of Southern California	30
Southern University and A&M College	9
State University of NY Maritime College	13
University of Texas	24
Texas A&M University	51
Tulane University	25
University of Utah	17
Vanderbilt University	26
Villanova University	60
University of Virginia	41
Virginia Military Institute	54
Virginia Polytechnic Institute	37
University of Washington	53
University of Wisconsin	26
Texas Technical University	11
TOTAL:	1,971

Source: Chief of Naval Education and Training (Code N-11)

Notes:
(1) Hampton Roads Consortium consists of Hampton University, Norfolk State University, and Old Dominion University. These three universities constitute one NROTC unit.

(2) The San Diego Consortium consists of the University of San Diego and San Diego State University. These two universities constitute one NROTC unit.

categories for fiscal year 1989. OCS is a part of the Naval Education and Training Center (NETC) in Newport, Rhode Island. NETC's fixed overhead costs (base support) are shared with

several training commands. These training activities include: Officer Candidate School, Officer Indoctrination School, Naval Academy Preparatory School (NAPS)[2], NETC Instructor Training School, Chaplain's School, Communications School, the Senior Enlisted Academy, and International OCS. Table 3.4 lists the prorated share of these costs assigned to OCS. CNET prorates these costs based on the number of reported man-months of training per training activity.

OCS reports the man-months of training it conducts to the Chief of Naval Education and Training Program Management Support Activity (NETPMSA) by means of the Navy Integrated Training Resource Administration System (NITARS).[3] This system is a software package that provides NETPMSA with the number of man-months of training performed. In fiscal year 1989, a discrepancy exists in the number of graduates reported from the OCS program. OCS reports that 1,233 people entered the program, and 974 people graduated. NETPMSA reports that the "equivalent number of graduates" is 723.75. NETPMSA arrives at this figure in the following manner. First, the number of man-months of training for the entire fiscal year, as reported by OCS (2,766 man months), is multiplied by a

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[2]As of 1 October 1990, NAPS has been removed from NETC's budget and placed on the Naval Academy's budget. Since this thesis is being used for future decisions, FY-1989 NAPS costs have been assigned to the Naval Academy instead of NETC.

[3]Man-months of training is defined as the sum of the total students trained per day for a particular month divided by the total number of instruction days per month.

conversion factor of 4.333 to estimate the number of man-weeks of training (11,985). Second, NETPMSA subtracts the

TABLE 3.4 FY-1989 NAVAL EDUCATION TRAINING COMMAND OCS COSTS (DOLLARS).

Cost Categories	O&M,N	MPN	St.P&A	TOTAL
1. Instructional Costs:				
a. Pay and Allowances for				
(1) Instructors				(1)
(2) Supervisor/Admin Support	58,104			58,104
b. Contract Instructors				(1)
c. Curriculum Material, supplies, contract, miscellaneous	101,548			101,548
d. Training equipment maintenance	36,836			36,836
2. Overhead Costs:				
a. Training Activity Commander Staff	78,145	3,001,216		3,079,361
b. Supplies, material, equipment, misc.	268,528			268,528
c. Temporary Additional Duty (TAD)				(2)
d. Curriculum development	10,411			10,411
e. Automated Data Processing (ADP)	125,715			125,715
3. Direct Student Costs:				
a. Student Pay and Allowances			6,922,607	6,922,607

TABLE 3.4 FY-1989 NAVAL EDUCATION TRAINING COMMAND OCS COSTS (DOLLARS) CONTINUED.

Cost Categories	O&M,N	MPN	St.P&A	TOTAL
4. Base Support:				
a. Installation, Command, and Staff	156,848	189,211		346,059
b. Supply	80,584	17,415		97,999
c. Logistics	6,569			6,569
d. Comptroller	18,068	4,246		22,314
e. Transportation	22,887			22,887
f. Personnel	9,074			9,074
g. Security	58,336			58,336
h. Facility Engineering	702,812			702,812
i. Safety				(2)
j. Morale, Welfare, and Recreation				(2)
k. Utilities	616,767			616,767
l. UPH (Unaccompanied Personnel Housing)				(2)
m. Supplies				(3)
n. Materials				(3)
o. Equipment				(3)
p. Maintenance				(3)
q. Contracts				(3)
r. Communications	291,522			291,522
s. Miscellaneous	540,281	20,541		560,822
TOTALS	3,183,035	3,232,629	6,922,607	13,338,271

TABLE 3.4 FY-1989 NAVAL EDUCATION TRAINING COMMAND OCS COSTS (DOLLARS) CONTINUED.

Source: Chief of Naval Education and Training Program Management Support Activity

Notes:
(1) This cost category has no dollars associated with it in the OCS accounting system.

(2) These costs are embedded in the miscellaneous category.

(3) Contract costs appear in the financial reports against specific expense elements of base functions without identification of particular contracts. Some functions are included in miscellaneous costs.

number of attrite weeks (405) from the number of training weeks. This accounts for those students who left the program at various stages of training but accrued various amounts of program costs. This yields the final amount of training weeks (11,580). Third, NETPMSA divides the total number of remaining training weeks by the number of weeks in the course (16) to estimate the number of graduates for the fiscal year (723.75).

This is the figure for the number of graduates that is used to report all cost per graduate figures provided by NETPMSA. It is considerably different from the 974 graduates reported by OCS. One source of error appears to be the amount of man- months of training reported. The 974 figure appears most accurate. However, this figure has not been adjusted to reflect the accrued costs by the people who attrited from the program at various stages during the 16 weeks. Therefore, this thesis will use the NETPMSA formula to achieve a new

equivalent number of graduates based on the final number of graduates (974) provided by OCS. The 974 graduates are multiplied by 16 weeks (the course length) to obtain 15,584 training man-weeks. Subtracting 405 attrite-weeks (provided by NETPMSA) from the total number of training man-weeks (15,584) yields 15,179 training man-weeks. Dividing this number by 16 weeks equals 948.69 equivalent number of graduates. This will be the figure used in the cost computations in this thesis.

B. METHODOLOGY

This thesis adopts the following methodology to obtain the marginal cost per graduate. First, the total cost of each of three commissioning programs is calculated. Second, the average cost per graduate for each program is calculated. This is used later for comparison with the marginal cost calculation. Third, each cost category is identified as being variable or fixed, or as containing elements of both categories. The criteria for the decision of whether the cost is variable, fixed, or both will be based on hypothetical cases that encompass the continuum from a one graduate change to incremental changes in the number of graduates. Fourth, for the Naval Academy, a prorated share of the variable costs are assigned to a graduating cohort, as discussed previously in the Barrow study. This is necessary because a graduating class shares in four fiscal years' of costs. Dividing this

cumulative total variable cost by the number of graduates yields the marginal cost per graduate.

Total variable cost divided by the number of graduates, is average variable cost. This analysis makes the implicit assumption that the average variable cost equals the marginal cost for all levels of output. This assumption is valid if the average productivity of labor and marginal productivity of labor are constant. The marginal productivity of labor is defined as "the change in output associated with a unit change in labor, holding other inputs constant." [Ref. 9:pp. 205-207] The average productivity of labor is defined as "the total production output divided by the number of units of labor employed." [Ref. 9:pp. 205-207] This seems to be a reasonable assumption because the change in the amount of graduates are assumed to be incremental changes. They are not likely to be large enough to significantly affect the productivity of each individual unit of labor at each of the commissioning sources.

Because total costs at the Naval Academy consist largely of fixed costs, the long-run results may be considerably different. This thesis will attempt to dissect the fixed cost functions for USNA to determine what costs would become variable in a five-year time period, if the number of graduates is reduced to approximately 800 midshipmen per year. The same procedure discussed above in the short-run analysis, will be used for this extrapolation into the long-run.

The methodology used to calculate marginal cost for NROTC is different in that the cost figures provided by CNET have been prorated for the four years that the students are enrolled in the program.[4] Also, since the cost data is combined for the entire program, separate marginal costs for the scholarship and non-scholarship programs, as well as for each individual NROTC unit, cannot be calculated. The marginal cost per graduate will actually differ for each of the 66 NROTC Scholarship and College programs, based on the differences in tuition and subsistence pay provided by the program. If decision makers were attempting to reduce the number of NROTC units, then individual unit average cost figures would be one important factor to consider in determining which units to close.

Since the OCS program is 16 weeks long, none of the courses overlap into another fiscal year in this computation, it is not necessary to prorate the cost of a class over more than one fiscal year.

The methodology discussed for each source will be repeated for incremental changes in the number of graduates to determine if any savings can be obtained by a change in the level of graduates.

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[4]These years are fiscal years 1986, 1987, 1988, and 1989.

IV. RESULTS

A. COST CALCULATIONS

This section accomplishes the following tasks: define which cost categories of each commissioning program are variable costs, fixed costs, or both; and determine what the total cost, average cost and marginal cost per graduate is for each source.

1. U.S. Naval Academy Short-Run Costs

The following discusses the cost functions in Table 3.1, and the reasoning behind the classification of those functions as variable, fixed, or both. The academic dean function is entirely fixed in the short-run. Reductions in student enrollment will not result in proportional reductions in faculty. There are 18 majors offered at the Naval Academy. When a reduction of 200 students, for example, is distributed over the 18 majors, it averages a reduction of 11 midshipmen per major. This change will improve the student-to-faculty ratio, but will not provide reason to reduce faculty.

The audio visual support function only has two civilian personnel providing service. The remaining support function is provided by contracting outside the Navy. This function is a fixed cost. The academic computer center function also is considered fixed. Under the military training function, the following subfunctions are assumed to

be variable: the Commandant's staff, which includes battalion and company officers; midshipmen travel funds; the professional development and programs department, which includes military instructors, (this could change because every midshipmen must take these courses); the leadership and law department program and instructors, (every midshipmen must also take these courses); the seamanship and navigation department; officer and civilian travel; small craft fuel; weapons training; sail training; fuel operations; and VTNA, the small plane club (every midshipmen is provided an opportunity for flying time). Under military training, only the Commandant's academic administrative subfunction is considered fixed.

The physical education function is considered as containing both fixed and variable elements. While the instructors may not change in the short-run, since they are spread across several sports, the equipment that the midshipmen use may change as enrollment changes. Thus, O&M,N Material under this function is considered a variable cost. The remaining outlays are assumed to be fixed. The library function is a fixed cost. The midshipmen mess function is considered as a fixed cost. If 500 midshipmen were eliminated from the brigade, spread over 36 companies, this would be equivalent to a reduction of 14 people, or two tables per company in the Mess. At most, in the long-run, this equates to approximately one fewer server per company. However, since

all food service attendants are contracted from outside the Navy, the contract will not change, in the short-run. Thus, this function is fixed.

The student services function has a total of 32 people, which are spread across the following areas: midshipmen activities, social activities, the midshipmen store, the Chaplain, and the midshipmen counseling center. Because the personnel are distributed among these subfunctions, the numbers per subfunction are too few to reduce. Therefore, small changes in student enrollment would not affect the student services function. Therefore, it is assumed to be a fixed cost.

The registrar is considered a fixed cost. Even if there are fewer midshipmen, there would also be more intensive screening of the applicants to select the smaller number of appointments. The student pay and allowances function is completely variable. The medical function is considered a fixed cost. This service is provided not just to midshipmen, but to service members and their families stationed at the Naval Academy. The band is considered a fixed cost. The civilian personnel office consists of 21 people. If the 1,627 civilians employed by the academy are reduced by a relatively small amount, this function will not change in the short-run. However, in the long-run this function may change.

The overall personnel administration function is considered fixed. The subfunction PSD (Personnel Support

Detachment) will not change unless there is a significant reduction in the number of military personnel stationed at the Academy and the naval station. The naval station subfunctions are a separate entity from the Academy and will not change with a change in the number of students enrolled. The special services function includes eight people and is unlikely to be reduced any further. This function is considered fixed. The remaining personnel services function includes: the equal opportunity office, human goals, safety, the bachelors officers' quarters (BOQ), the commissioned officers and faculty club, the enlisted club, the naval station Chaplain, and the legal office. The 27 personnel, when spread across these subfunctions, leave just enough people per subfunction that they cannot be reduced any further. Because these subfunctions also support more than just midshipmen, this function is considered fixed.

The utilities and custodial services functions are provided by contractors and are viewed as fixed. The fire protection, maintenance and engineering, and base communications functions also are considered fixed costs. The transportation, operations, and equipment maintenance function is viewed as containing both fixed and variable elements. The L7 subfunction, which includes the buses for midshipmen transportation is treated as variable because the academy will not require the same amount of buses with a

change in the number of midshipmen. Also, bus maintenance is variable.

The Commissary and food services function is viewed as a fixed cost. The subfunctions of the Commissary and Navy Exchange will not change with a change in the number of students enrolled, for they also provide services to base military personnel and their families. The supply and services function is considered fixed with one exception. The midshipmen laundry services is viewed as a variable cost. The laundry makes up 7.2 percent of the total cost of this function. All of the following functions are considered fixed: comptroller; security; military support unit (Bachelors Enlisted Quarters); the museum; the public affairs office; and the command and staff function (which includes the Commanding Officer of the naval station, and the Superintendent of the Naval Academy and his personal staff).

The Naval Academy Preparatory School has elements of both fixed and variable costs. The O&M,N and MPN subfunctions are treated as fixed, while the military pay for students is viewed as variable. It makes sense that if the Academy is selecting fewer midshipmen to enter, the preparatory school would also be reduced in size. Currently, there is a proposal by the Department of Defense to consolidate all service academy preparatory schools into one school. If this occurs, the costs would likely be prorated to their respective

academies. Therefore, the preparatory school costs are still considered relevant.

Appendix A provides all of the Academy data to estimate the costs for the class of 1989. Appendix B provides the actual computations. Table 4.1 provides a summary of the short-run results. These results were obtained by prorating the total costs of operating the Academy for fiscal years 1986 through 1989 by the percent of the brigade that the class of 1989 represented. For fiscal years 1986, 1987, 1988, and 1989, the percentages are respectively 28.8, 24.9, 23.5, and 23.1. The total fixed costs comprised 63.3 percent of the total cost associated with the class.

The total variable costs were 36.7 percent. This confirms that the majority of Naval Academy costs are fixed, and that a marginal cost analysis is preferred to an average cost analysis when determining the effects of incremental changes in the student body. This also provides some legitimacy to the idea that economies of scale may affect the long-run average cost. The established fixed costs may allow for a reduction in the average cost per graduate as the number of graduates increase the long-run. This implies increasing returns to scale. Further research in this area is warranted.

2. U.S. Naval Academy Long-Run Costs

This section will only discuss those costs which appear to change from fixed to variable in the long-run. The discussion in the previous section is relevant for the costs

TABLE 4.1 USNA FY-1989 SHORT-RUN COST RESULTS.

NUMBER OF GRADUATES:	1,082
TOTAL COST:	$ 167,553,973
AVERAGE COST:	154,856
TOTAL FIXED COSTS:	105,996,506
TOTAL VARIABLE COST:	61,557,467
MARGINAL COST PER GRADUATE:	$ 56,892

that will remain variable or fixed in the long-run.

This long-run analysis is based on straight proportions. It is prudent to keep in mind that not all fixed costs will react to changes in enrollment proportionally. For example, utility usage rates will vary depending on how the brigade is organized. Two variations of this would encompass entire companies being eliminated, and wings of Bancroft Hall being closed, or midshipmen could be eliminated from each company, reducing occupancy in all rooms to two people. Utilities will be used differently for each version. Thus utilities may not be reduced proportionally to the change in enrollment.

In the long-run, a reduction of 200 graduates per year over four years, or 800 midshipmen (not accounting for attrition), would equate to reducing on average 45 midshipmen in each of the 18 academic majors. Once again, however, this will not occur proportionally. Since projecting the future choices of majors is not realistic, it is assumed that the

student-to-faculty ratio will remain at approximately ten to one. This amounts to reducing faculty costs 20 percent.

While the academic computer center will remain open, materials used will most likely be reduced by 20 percent. This reduces the overall costs of the computer center by 6 percent. If the 40 library personnel were reduced by approximately six, or 15 percent, this would reduce overall library costs by seven percent.

In the midshipmen mess, if 20 percent of the servers were reduced (O&M,N labor), this would equate to a reduction in total function costs of nine percent. If the Academy were accepting 1,100 applicants instead of approximately 1,400, this would proportionally reduce the number of employees in the admissions section of the registrar from ten to eight, thereby decreasing overall expenses by three percent.

Though utility capacity equations were unavailable, a proportional decrease of 20 percent in usage (O&M,N material) equates to a decrease in 16 percent of the costs of the utilities function. A decrease from 1,400 admissions to 1,100 equals a 22 percent decrease in admissions. If the preparatory school were decreased by approximately ten percent, this would reduce the overall cost function by ten percent.

All of the changes discussed above result in a decrease of 122 civilian personnel, or a nine percent reduction. Therefore, a nine percent reduction in the

civilian personnel office function is assumed. Since the Personnel Support Detachment (PSD) serves both the military personnel assigned to the Naval Academy and the naval station, it is not practical to estimate the reductions in the PSD.

The reductions discussed above, form the basis for the calculations in Appendix B, and yield the results shown in Table 4.2. These results are based on a reduction in the number of graduates from 1,082 to an average of 800 per year, a 20 percent decrease. These cost results will not be compared to the costs of the NROTC and OCS program, because the costs of the latter two programs are exclusively short-run costs, and do not take into account any long-run changes.

TABLE 4.2 USNA LONG-RUN COST RESULTS.

NUMBER OF GRADUATES:	800
TOTAL COSTS:	$ 167,553,973
AVERAGE COST:	209,443
TOTAL FIXED COSTS:	60,155,636
TOTAL VARIABLE COSTS:	107,398,337
MARGINAL COST PER GRADUATE:	$ 134,248

3. NROTC Costs

The Military Pay, Navy (MPN) category of costs is for the Navy staffing of the NROTC units. This staffing includes

a unit Commanding Officer, Executive Officer, three to four Navy officer instructors (depending on the particular unit, it could be as many as five instructors), one Marine Corps Captain or Major, one E-6 or E-7 Yeoman (YN), one E-6 or E-7 Storekeeper (SK), one E-6 or E-7 Quartermaster (QM), and a civilian, usually at the GS-5 level. If the number of students in the program changed by a large amount, perhaps one, or at most two, Navy officer instructors could be either added or subtracted. For the most part, at the margin, this staffing arrangement is fixed; therefore, the costs associated with this category are also fixed.

The Reserve Personnel, Navy (RPN) category, which includes the travel costs for Midshipmen during summer cruises, uniforms, the subsistence allowance, and the naval science textbooks, is primarily a variable cost category. The Operations and Maintenance, Navy (O&M,N) category is a mixture of variable and fixed costs. While tuition is considered variable, the program/unit operations costs are fixed in the short-run. These costs would become variable in the long-run, especially when the prospects of closing a NROTC unit is under consideration. The NROTC headquarters is a part of CNET's staff, and their costs are incorporated into CNET. They are not a part of the direct costs for the NROTC program. These costs are a part of activity group NX, while the NROTC program costs are activity group L8. Based on the costs listed in Table 3.2, the total, average, and marginal costs for fiscal

year 1989, based on 1,971 graduates, are listed in Table 4.3.[5] Based on the results shown in Table 4.3, fixed costs make up 34.9 percent of NROTC total program costs, while average costs make up 65.1 percent. Therefore, incremental changes to the number of graduates should have more of an impact because total variable costs make up a higher percentage of the total costs.

TABLE 4.3 NROTC FY-1989 COST RESULTS.

NUMBER OF GRADUATES:	1,971
TOTAL COST:	$ 97,527,000
AVERAGE COST:	49,481
TOTAL FIXED COSTS:	34,032,000
TOTAL VARIABLE COST:	63,495,000
MARGINAL COST PER GRADUATE:	$ 32,215

4. OCS Costs

Of all the OCS costs listed in Table 3.4, the following cost categories are considered variable: instructional costs for curriculum materials, supplies, contract, and miscellaneous; the supplies, material, equipment, and miscellaneous for overhead costs; and the

[5]This number is different from the 1,618 graduates reported in Mrs. Pope's testimony before the Senate Subcommittee for Manpower as shown in Table 1. Since the 1,971 figure is reported from the NROTC headquarters, it is accepted as the accurate estimate.

student pay and allowances. Those cost categories that are fixed include: instructional costs for supervisory, administrative and support personnel; and training equipment maintenance (assuming that maintenance contracts are annual contracts and fixed for the short-run). The following overhead costs are considered fixed: the training activity commander's staff (which includes the salaries of the Navy instructors); curriculum development, and automated data processing (ADP).

If OCS were to change their enrollment substantially, then the number of Navy instructors, and perhaps the ADP funding might change. However, for small incremental changes, these costs are virtually fixed. The base support cost categories are fixed, and these costs are shared with the other training activities at the Naval Education and Training Center. These costs include: installation command and staff; supply; logistics; comptroller; transportation; civilian personnel; security; facility engineering; safety; morale, welfare and recreation; utilities; supplies; materials; equipment; maintenance; contracts; communications; and unaccompanied personnel housing (UPH). The base support costs are 45.2 percent of the program's fixed costs. Student pay and allowances are 94.9 percent of the total variable costs, and 51.9 percent of the total costs. This makes them the largest single cost factor affecting the OCS program. Table

4.4 lists the results of the cost calculations for OCS based on 948.69 graduates.

TABLE 4.4 OCS FY-1989 COST RESULTS.	
EQUIVALENT NUMBER OF GRADUATES:	948.69
TOTAL COST:	$ 13,338,271
AVERAGE COST:	14,060
TOTAL FIXED COSTS:	6,045,588
TOTAL VARIABLE COST:	7,292,683
MARGINAL COST PER GRADUATE:	$ 7,687

B. SENSITIVITY ANALYSIS

The marginal cost results allow for a sensitivity analysis of the change in cost that will occur with a change in the student enrollment at the three commissioning sources. This sensitivity analysis follows.

1. U.S. Naval Academy

The short-run marginal cost of an Academy graduate is calculated to be $56,892. Multiplying the marginal cost per graduate by the change in the number of graduates will yield the change in total cost. For example, if we reduce the number of graduates from the Naval Academy by approximately 200 per year, as recommended in the Department of Defense report discussed in Chapter II, the total savings to the Navy would be $11,378,400. This is approximately 6.8 percent of

the total cost of the program. Reducing the graduating class size by 100, would yield a savings of $5,689,200, approximately 3.4 percent of the total cost.

In the long-run, if the assumptions used in making the proportional changes in fixed costs are approximately correct, reducing the size of the brigade by approximately 800, an average reduction of 200 graduates per year, would equate to a marginal cost per graduate of $134,248. This would yield a savings of $107,398,400 ($134,248 X 800) over a four-year period of time.

2. Naval Reserve Officers Training Corps

The marginal cost of an NROTC graduate is calculated to be $32,215. A ten percent reduction in the number of graduates, or 197 graduates, yields a reduction in cost of $6,346,279. This equates to a savings of 6.5 percent of the total cost of the NROTC program. A reduction of 19 percent, as recommended in the Department of Defense report, would equate to 375 fewer graduates and a savings of $12,081,479. This is 12.4 percent of the total costs. A reduction of this size may not be accomplished without the closing of NROTC units. If this is necessary, a breakdown of the costs by unit would be necessary to provide a more accurate sensitivity analysis. Moreover, full average cost would become relevant in this situation.

3. Officer Candidate School

The marginal cost for an OCS graduate is $7,687. A decrease in the number of graduates by 100, or approximately 10 percent, would yield a $768,722 savings, or approximately 5.76 percent of total program cost. A reduction of 200 graduates per year, approximately 21 percent, would equate to a savings of $1,537,400, or 11.5 percent of the total program cost.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The results clearly show that there are pronounced differences in the cost of graduating an officer from the Naval Academy, NROTC, and OCS. Regardless of which type of cost is used to compare the three sources, the rank order remains the same: the Naval Academy remains the most costly, followed by NROTC, and then OCS. Several studies, discussed in this thesis, have compared commissioning sources using the average cost per graduate. However, this thesis argues that marginal cost is a more relevant comparison if the decision maker has decided against closing the source completely, particularly in the short-run. For example, if average cost were used to determine the short-run savings for the Naval Academy from a decrease of 200 graduates per year, the estimated savings would be $31.6 million ($154,856 X 200). The estimated savings falls to $11.4 million ($56,892 X 200) when marginal cost is used. Because of the large fixed costs at the Academy, the perceived savings would be overestimated in the short-run using average cost.

In comparing the marginal cost factors across sources, one sees that the cost categories are similiar. These categories include student pay and allowances, instructional costs for the classroom (curriculum materials, supplies), transportation

expenses, tuition for NROTC, and military and physical education training costs for the Naval Academy. In comparing average cost factors across the sources, the categories are vastly different, especially for the Naval Academy with its large fixed assets. When comparing the three sources, it is interesting to note the differences in the composition of total cost. Table 5.1 illustrates these percentages.

TABLE 5.1 TOTAL COST COMPOSITION AMONG COMMISSIONING SOURCES.

Source	Percent Fixed Costs	Percent Variable Costs
USNA	63.3	36.7
NROTC	34.9	65.1
OCS	45.3	54.7

The Naval Academy is the only source where fixed costs comprise a majority of the total costs. This is the reason why marginal costs are closer for each source than are average costs, as shown in Table 5.2.

TABLE 5.2 FY-1989 MARGINAL COST PER GRADUATE.

Source	Marginal Cost
USNA	$ 56,892
NROTC	32,215
OCS	7,687

1. The Costs and Benefits of This Research

This thesis potentially benefits Navy manpower planners in Washington. It provides a timely marginal cost analysis that will assist in the decision-making process of officer force reductions. It also recommends areas of further research.

This study, and subsequent force reductions, will have negative spillover effects, particularly for the commissioning sources, and the young Americans that will not receive appointments because of reduced officer requirements. Taken as the sole justification for reducing commissioning sources, the more expensive institutions should be reduced in favor of the cheaper sources. This may not be the most advantageous method. Further research on the productivity of officers by commissioning source, and the efficiency of each source is warranted.

For NROTC, the institutions that are the most costly may receive fewer resources to accomplish their mission. If all of the most costly units receive the same proportional cut, this will force the inefficient units, if any, to become more efficient. However, this would also degrade the capabilities of efficient units. Cost alone, should not be the deciding factor.

The reduction of officer accessions will reduce the opportunity of those young Americans that desire to attend the more costly, perhaps more prestigious schools in the country.

For example, if NROTC scholarships to the Massachusetts Institute of Technology (MIT) were reduced in favor of a less expensive college, perhaps the Navy would lose those high quality applicants desiring to attend MIT.

2. Alternatives

There are alternatives to, and extensions of, a marginal cost analysis that are important to consider when contemplating reductions in officer recruitment. A true cost-benefit analysis would consider all of the relevant issues of the subject. This thesis focused on just a small portion of the issue concerning officer accession sources. A natural extension of a short-run marginal cost analysis would be a long-run analysis where altering fixed capital, such as facilities, would be an option. Closing a commissioning source, such as the Naval Academy, could be an option in this type of study. A long-run study could analyze every possible option. Based on monetary costs alone, the Navy could save a considerable amount in the long-run. This type of analysis should also consider the political permutations involved. This type of action may result in the Navy losing some of its direct ties with Congress, on the local level, due to reduced involvement through the nomination process.

An alternative study might include an examination of the comparable costs of students attending civilian universities and colleges. This adds a perspective that Navy decision-makers could use as a comparison.

An examination of the social costs and impact of reducing and/or closing NROTC units at universities is also necessary. The savings to the Navy might not justify the spillover effects to society (in the form of less income for universities and surrounding businesses), and the lack of political support by local Congressmen. The non-economic costs of reducing NROTC commissions should also be examined. The Navy may lose valuable visibility on those civilian college campuses where NROTC units are terminated, perhaps losing recruitment opportunities of high quality college youth for NROTC and OCS.

NROTC also provides 33 percent of the Navy's black officers and 20 percent of its Hispanic officers. Six of the NROTC units are an important source of minority accessions because they are located on historically black campuses.[6] [Ref. 16] Reducing commissions through NROTC without an examination of the spillover effects to the Navy's equal opportunity goals, might further exacerbate efforts to reach the seven percent black, and four percent Hispanic minority commission targets. [Ref. 17] Likewise, in fiscal year 1988, OCS graduated 59 percent of the newly commissioned Hispanic officers and 50 percent of the newly commissioned black officers [Ref. 16]. An alternative study might also include

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[6]The historically black colleges with NROTC units are: Florida A&M University, Southern University and A&M College, Savannah State College, Prairie View A&M University, Morehouse College, and the consortium of Hampton University, Norfolk State University, and Old Dominion University.

the effects on minority goals of significantly reducing commissions via this source. This type of study may help balance equal opportunity needs with efficient and effective reductions in accessions.

OCS provides the major avenue for civilian college graduates to obtain a commission in the Navy. Decreasing this source of commission would eliminate this source of employment for some college graduates. OCS also commissions the highest percentage (32 percent) of nuclear surface/submarine officer accessions. In addition, the Navy receives the majority of its supply officers from OCS. If the Navy limits the effect of the reductions on the nuclear and supply officers, there may be an overall shortage in the number of commissions of surface warfare officers. A follow-on study should include the long-run impact of reducing officer commissions on each officer community. The objective would be to prevent future shortages in any specific community.

OCS is also a path for enlisted personnel to achieve a commission after obtaining their degree while on active duty. Reducing OCS commissions limits this opportunity. For those who do receive a commission, the Navy incurs a cost to refill that enlisted billet. However, the benefit is a more "seasoned" officer.

The non-economic alternative studies discussed above should be examined in addition to the long-run cost analysis. The likelihood of closing traditional institutions, such as

the Naval Academy, are remote at best. However, the spillover effects of the non-economic costs could cause shortages of officers in different communities and affect long-term Navy goals.

Included in the alternatives that policy makers should consider when restructuring officer accession programs are other factors that cannot be quantitatively measured in a thesis. Perhaps Mrs. Pope was trying to capture these factors when she stated:

> Although the education of the individual is a major benefit of the USNA and NROTC programs, this is not what makes them unique. Instead, it is the development of a cadre professional military officer force deeply imbued with the highest traditions and heritage of the naval service, dedicated to a career of service to their country. [Ref. 1:p. 1]

B. RECOMMENDATIONS

From the conclusions drawn in the first section of this chapter, the first recommendation of this thesis is for decision makers to use marginal cost for any comparative analysis of commissioning sources in the short-run. Marginal cost particularly should be used for any estimations of the savings to be gained by reducing the number of graduates.

All three commissioning sources provide high quality officers. The unique characteristics of each source, when considered with the relatively small differences between short-run marginal costs per graduate, lead one to the conclusion that all three sources must be maintained to

provide an optimal mix of accessions to meet the demands of the Navy at any point in time.

Therefore, the second recommendation of this thesis is that no commissioning source be completely eliminated on the basis of cost alone. If the Department of Defense must reduce officer accessions, then incremental reductions from the more costly Naval Academy and NROTC programs would seem appropriate.

An optimal mix of officers should be determined based on the current and projected needs of the Navy. The third recommendation of this thesis is for the Navy to develop a goal programming model to determine the most effective number of officer accessions from each source. This analysis should consider the current and projected constraints the Navy is facing, and the goals of the nation's leaders as well as the leaders in the Departments of Defense and Navy. Once this complex yet flexible model is developed, it can be altered to reflect the present issues, and then included in a decision support system for all policy makers.

The data for this research was spread across the United States including Newport, Rhode Island, CNET in Florida, Annapolis, Maryland, and Washington, DC. The data received were not directly comparable. Discrepancies existed in the number of fiscal year 1989 graduates from each of the three commissioning sources. Where a discrepancy existed, the numbers from the actual commissioning source were used. The

Army uses a system called the Army Manpower Cost System (AMCOS) in which all costs for commissioning sources may be found.

The fourth recommendation of this thesis is to create a centralized database where all of the correct, raw, disaggregated, cost data is collected after it has been approved by the Navy. This will help alleviate discrepancies. One discrepancy includes differences in the reported amount of actual man-months of training conducted by OCS in fiscal year 1989. In addition, the Naval Academy reported that 1,082 officers graduated in fiscal year 1989, while the Assistant Secretary of the Navy for Manpower and Reserve Affairs reported that 958 midshipmen graduated. Finally, the Congressional Budget Office reported that the Navy commissioned 7,800 officers in fiscal year 1989, while the Assistant Secretary of the Navy for Manpower and Reserve Affairs reported 6,554 officer accessions. All this data was suppose to have come from the same source, the U.S. Navy. The point is not to find fault with any of the sources of information. However, it is important to note that there are discrepancies in the data.

The formulation and maintenance of an all encompassing database would be costly. However, the benefits may outweigh the costs considering the importance that Congress, DOD, and DON place on restructuring the military through enlisted recruitment and officer accessions. Other stakeholders, such

as the Congressional Budget Office (providing research for the Congress), the Center for Naval Analyses (providing research for the Department of Defense), and the Government Accounting Office would be interested in this complete master database. The time and energy used to reproduce this data for various inquiries might be worth the costs involved. This database could be tied into the decision support system which embodied the goal programming model recommended above.

Fifth, further research should be conducted in the area of a long-run cost analysis. While this thesis used broad, proportional reductions to show possible effects in the long-run, exact unit measurements would be more precise. This research could also include an estimation of the effects of economies of scale, discussed previously in this thesis. Evidence from other research indicates that economies of scale do exist in public education systems with a large capital base. If this is true at the Naval Academy, then the Navy's returns to scale should be determined. If the Academy is on the increasing returns to scale portion of the cost curve, then increasing the number of graduates through the Academy would reduce the average and marginal cost per graduate, up to a certain point. Further research in this area may show that the Navy can use its established capital assets more efficiently by shifting more of its accessions to USNA.

Sixth, because the non-economic costs of reducing officers accessions were not explored in this thesis, but are essential

to effective decision-making processes, further research into these costs is warranted.

In the long-run, reductions in the number of commissions will likely be shared by all three sources. In the interim, based on cost alone, USNA and NROTC should incur relatively greater reductions, while OCS will remain a flexible source, throttling accessions in the short-run to make up for any gaps in the officer force structure. In the end, the Navy must retain the ability to produce quality officers from all three sources, while maintaining the flexibility to increase officer end-strength, should the need arise.

APPENDIX A. USNA COST DATA

TABLE A.1 FY-1989 USNA COSTS BY SUBFUNCTION

Item	Function	O&M,N Labor	O&M,N Material	MPN	TOTAL
1.	ACADEMIC DEAN				
a.	Academic Dean	932737	492591	134017	1559345
b.	Director Research	148112	24563		172675
c.	Travel		27658		27658
d.	Honors Program		142071		142071
e.	SECNAV Fellows		75012		75012
f.	Academic Center	72709	15799	87302	175810
g.	Search Committ.		2630		2630
	Div. Eng & Weps				
h.	Admin Support	78428	50595	674690	803713
i.	Technical Supp.	1930807	199444		2130251
j.	Aerospace Eng.	721406	165652	289104	1176162
k.	Electrical Eng.	1002418	379330	983192	2364940
l.	Mech. Eng.	1465595	406674	656976	2529245
m.	Naval Sys. Eng.	1215767	226079	1249428	2691274
n.	Weapons Eng.	730071	474632	1050156	2254859
o.	CADIG	281019	224454		505473
p.	Hydrochem. Lab	331270	110444		441714
	Div. English/History				
q.	Admin Support	61001	50397	205190	316588
r.	English	1535639	165182	484692	2185513
s.	History	1711454	137640	537737	2386831
t.	Forensics		10664		10664
	Div. Math & Science				
u.	Admin Support	169057	114875	153324	437256
v.	Chemistry	1446054	435766	444553	2326373
w.	Applied Sci.	646646	156749	795485	1598880
x.	Oceanography	418689	256990	746357	1422036
y.	Mathematics	2940395	304779	1288028	4533202
z.	Physics	1849056	525670	585369	2960095
	Div. US & International Studies				
aa.	Admin Support	99721	40867	190834	331422
bb.	Area Language	850989	126016	91020	1068025
cc.	Economics	780038	50068	466325	1296431
dd.	Political Sci.	891969	125323	365175	1382467

TABLE A.1 FY-1989 USNA COSTS BY SUBFUNCTION CONTINUED.

Item	Function	O&M,N Labor	O&M,N Material	MPN	TOTAL
	Other				
ee.	Foreign Officers			594448	594448
ff.	Other Services			994897	994897
TOTAL		22311047	5518614	13068299	40897960
2.	AUDIO VISUAL SUPPORT				
a.	Educ. Resources	70962	787909		858871
TOTAL		70962	787909		858871
3.	ACADEMIC COMPUTER CENTER	1858506	977697	411321	3247524
4.	FACULTY TRAINING				
5.	MILITARY TRAINING				
a.	Commandant & staff	439565	236690	4151358	4827613
b.	Mid. travel		1639516		1639516
c.	Dir. PRODEV	109405	71553	572181	753139
d.	Comdt. Academic Admin	24171	28940		53111
e.	Leadership & Law	245536	20600	1277233	1543369
f.	Seamanship & Nav	22506	41511	3220104	3284121
g.	Officer/Civ Travel		109642		109642
h.	Small Craft Fuel		128282		128282
i.	Small Craft Fac	1853765	859698	4859253	7572716
j.	Weapons Training	52596	39654	168976	261226
k.	Sail Training	268164	548198	827591	1643953
l.	Fuel Operations		106881		106881
m.	VTNA		158877		158877
TOTAL		3015708	3990042	15076696	22082446
6.	PHYSICAL EDUCATION	1865291	411372	1421272	3697935
7.	LIBRARY				
a.	Library	1454649	1220022		2674671
b.	Archives	119364	39722		159086
TOTAL		1574013	1259744		2833757
8.	MIDSHIPMEN MESS				
a.	Mid. Food Ser.	3054736	705907	388023	4148666
b.	Wardroom Contract		2363483		2363483
c.	Equip. Purch.		2626		2626
TOTAL		3054736	3072016	388023	6514775

TABLE A.1 FY-1989 USNA COSTS BY SUBFUNCTION CONTINUED.

Item	Function	O&M,N Labor	O&M,N Material	MPN	TOTAL
9.	STUDENT SERVICES				
	a. Mid. Activities & Social Activ	31001			31001
	b. Mid. Activities	180741	5738		186479
	c. MRAF Officer			63309	63309
	d. Chaplain	142755	97131	702323	942209
	e. Counseling Ctr.	23393	6544	211921	241858
TOTAL		377890	109413	1115168	1602471
10.	REGISTRAR				
	a. Publications				0
	b. Admissions	380125	127096		507221
	c. Registrar	240288	25527		265815
	d. Nominations & Appointments	144474	10497		154971
	e. Candidate Guid.	228120	190258	1231497	1649875
	f. Travel		101318		101318
	g. Recruiting Funds		108000		108000
TOTAL		993007	562696	1231497	2787200
11.	STUDENT PAY AND ALLOWANCES				
	a. Base Pay			27053410	27053410
	b. Rations			6025368	6025368
	c. FICA			2016191	2016191
TOTAL				35094969	35094969
12.	MEDICAL				
	a. Dental Clinic	101700		1411438	1513138
	b. Medical Clinic	69539		2334541	2404080
	c. Veterinary Services			40291	40291
	d. NMRC Bethesda		491656		491656
	e. Anne Arundel Hospital		54600		54600
TOTAL		171239	546256	3786270	4503765
13.	BAND		23105	1108523	1131628
14.	PRINTING PLANT				
15.	ADMIN DATA PROCESSING				
16.	CIVILIAN PERS.	1062751	97832		1160583
17.	PERSONNEL ADMINISTRATION				
	a. Pers & Admin	231809	141119	276163	649091
	b. NAVSTA Admin	181118	43520	771775	996413
	c. NAVSTA Travel		43133		43133
	d. PSD	180376		285028	465404
TOTAL		593303	227772	1332966	2154041

TABLE A.1 FY-1989 USNA COSTS BY SUBFUNCTION CONTINUED.

Item	Function	O&M,N Labor	O&M,N Material	MPN	TOTAL
18.	SPECIAL SERVICES	36511	95080	146328	277959
19.	OTHER PERSONNEL SERVICES				
	a. Search Committee				0
	b. PCS				0
	c. EEO	118369	8873		127242
	d. Human Goals	238250	30403	66590	335243
	e. Safety	208585	51442	125879	385906
	f. BOQ		32015	38667	70682
	g. O&F Club				0
	h. Enlisted Club				0
	i. NAVSTA Chaplain	20644	14305	86596	121545
	j. USNA Legal Off.	32449	4649		37098
	k. Club Support				0
	l. Equipment Lease				0
TOTAL		618297	141687	317732	1077716
20.	UTILITY SERV.	1355996	6166472		7522468
21.	CUSTODIAL SERVICES		2989576		2989576
22.	FIRE PROTECTION	1358566	53989		1412555
23.	MAINTENANCE & ENGINEERING				
	a. Admin	109133			109133
	b. Recur. Maint.	7306153	6380302		13686455
	c. Non-rec. Maint.		9537962		9537962
	d. Gen. Maint.	2625259	4609729		7234988
	e. Minor Constr.	8631	47890		56521
	f. Pers. Supp.	56734	26008		82742
	g. Mission Ops.			328892	
	h. Minus M2/R2		9308146		9308146
	i. UA CBU 403		67603	1012627	1080230
TOTAL		10105910	11361348	1341519	22808777
24.	COMMUNICATIONS				
	a. Base Services	180658	1290305		1470963
	b. Comm. only		96290	304184	400474
	c. 50% Comm. Offset		44598	152092	196690
TOTAL		180658	1341997	152092	1674747
25.	TRANS. OPS. & EQUIP MAINT.				
	a. Ops/Maint.	1068653	594611		1663264
	b. Supply	102714			102714
TOTAL		1171367	594611		1765978

TABLE A.1 FY-1989 USNA COSTS BY SUBFUNCTION CONTINUED.

Item	Function	O&M,N Labor	O&M,N Material	MPN	TOTAL
26.	COMMISSARY & FOOD SERVICES				
	a. Navy Exchange			31655	31655
	b. Commissary Store (50%)	187433		104591	292024
	c. Food Service	19413		414818	434231
TOTAL		206846		551064	757910
27.	SUPPLY & SERVICES OPS.				
	a. Supply	1076557	224425	558303	1859285
	b. NAVSTA Supply	69419	280318	204599	554336
	c. Laundry		188366		188366
TOTAL		1145976	693109	762902	2601987
28.	LOGISTICS				
29.	COMPTROLLER				
	a. Comdt. & Staff	100218		63309	163527
	b. Deputy for Mngmt.	760018	290032	270356	1320406
	c. PSD (Disburs. Only)	160786		196090	356876
	d. Centralized Civilian Pay	34296			34296
TOTAL		1055318	290032	529755	1875105
30.	SECURITY				
	a. Phys. Ed.			192154	192154
	b. Comdt. Guards	101119	67669	63074	231861
	c. Security Dept.	1135152	41486	74053	1250691
	d. Marines		17793	1308045	1325838
	e. 1st Lt.	37910	7752	424185	469847
	f. Nav. Investigative Service	96038	6200		102238
TOTAL		1370218	140900	1511118	3572629
31.	PREP SCHOOL				
	a. O&M,N/MPN	540303	934469	1371711	2846483
	b. Military Pay Stud.			3063356	3063356
TOTAL		540303	934469	4435067	5909839
32.	PCS TRAVEL				
33.	MILITARY SUPPORT UNIT		45240	198018	243258
34.	MUSEUM	183248	14572		197820
35.	PAO	391529	320066	332436	1044031

TABLE A.1 FY-1989 USNA COSTS BY SUBFUNCTION CONTINUED.

Item	Function	O&M,N Labor	O&M,N Material	MPN	TOTAL
36.	COMMAND & STAFF				
	a. Superintendent & Staff	82208	77361	871662	1031231
	b. CO NAVSTA	21052	500	104086	125638
	c. Contingency Funds of Supt.		49842		49842
TOTAL		103260	127703	975748	1206711
37.	ALL OTHER FUNCTIONS				
38.	STEWART ARMY ANNEX				
ACADEMY TOTAL		56772496	42895319	85839176	185506991

Notes: (1) All notes for Table 3.1 pertain to this Table.

TABLE A.2 FY-1986 THROUGH FY-1988 USNA COSTS BY FUNCTION

Item	FY-1986	FY-1987	FY-1988
1.Ac.Dean	27326962	31030000	38115438
2.Audio/Visual	680081	570000	908838
3.Acad. Computer	2393634	2458272	3032534
4.Faculty Train.			
5.Military Train	20727414	21336556	24048914
6.Phys. Ed.	3491555	3555456	3805867
7.Library	2081989	2268784	2703820
8.Mid. Mess	6867972	6254192	6406529
9.Stud. Services	1150233	1382935	1068095
10.Registrar	2391755	3284322	2667185
11.Stud. Pay	33455586	33479464	34610260
12.Medical	5372678	5976740	2901128
13.Band	1829019	1960420	1899947
14.Printing Plant			
15.Admin Data Proc.			
16.Civilian Pers.	973425	1020824	973405
17.Pers. Admin	1785546	2157158	3065007
18.Spec. Serv.	479952	549704	704640
19.Other Pers.Ser.	1379988	1564675	1394566
20.Utilities	7108925	6958540	6108269
21.Custodial Ser.	3254127	3276589	2431092
22.Fire Protect.	1166355	1272105	1320532
23.Maint.& Eng.	13929354	14070945	16160855
24.Communications	1415852	1471986	1248269
25.Trans.Equip.	1570693	1718208	1625518
26.Commissary	1287371	1573653	1298824
27.Supp.& Serv.	1870023	1984804	2065001
28.Logistic Activities			
29.Comptroller	1548148	1574117	1862952
30.Security	2234602	2421934	3463188
31.Prep School	4406558	4582820	5313046
32.PCS Travel	422041	434702	(1)
33.Mil.Supp.Unit	427936	445053	474418
34.Museum	158686	167530	176114
35.Public Affairs	873650	906671	954273
36.Command & Staff	882533	893943	1230677
37.All Other Functions			
38.Stewart Army Subpost			
TOTAL	155040216	162701748	174039201

Notes: (1) PCS Travel was omitted from cost functions since FY-1988 because these costs were found to also be included in the MPN account. Since they were counted before FY-1988, those figures available were used in the marginal cost calculations.
(2) All notes in Table 3.1 are pertinent to this Table.

APPENDIX B. USNA MARGINAL COST CALCULATIONS

TABLE B.1 USNA SHORT-RUN MARGINAL COST CALCULATIONS

Item	FY-1989		FY-1988		FY-1987		FY-1986	
	F	V	F	V	F	V	F	V
1.	40897960		38115433		31030000		27326962	
2.	858871		908838		570000		680081	
3.	3247524		3032534		2458272		2393634	
4.								
5.	53111	22029335	57958	23990956	51421	21285135	49953	20677461
6.	3286563	411372	3254314	551553	3159947	395509	3103154	388401
7.	2833757		2703820		2268784		2081989	
8.	6514775		6406529		6254192		6867972	
9.	1602471		1068095		1382935		1150233	
10.	2787200		2667185		3284322		2391755	
11.		35094969		34610260		33479464		33455586
12.	4503765		2901128		5976740		5372678	
13.	1131628		1899947		1960420		1829019	
14.								
15.								
16.	1160583		973405		1020824		973425	
17.	2154041		3065007		2157158		1785546	
18.	277959		704640		549704		479952	
19.	1077716		1394566		1564675		1379988	
20.	7522468		6108269		6958540		7108925	
21.	2989576		2431092		3276589		3254127	
22.	1412555		1320532		1272105		1166355	
23.	22808777		16160855		14070945		13929354	
24.	1674747		1248269		1471986		1415852	
25.	1171367	594611	1148499	477019	1139687	578521	1041841	528852
26.	757910		1298824		1573653		1287371	
27.	2413621	188366	1915516	149485	1841124	143680	1734652	135371
28.								
29.	1875105		1862952		1574117		1548148	
30.	3572629		3463188		2421934		2234602	
31.	934469	4975370	840099	4472947	724636	3858184	696765	3709793
32.					434702		422041	
33.	243258		474418		445053		427936	
34.	197820		176114		167530		158686	
35.	1044031		954273		906671		873650	
36.	1206711		1230677		893943		882533	
37.								
38.								
TOTAL VC		63294023		64252220		59740493		58895464

Percent of Brigade:	FY-1989	FY-1988	FY-1987	FY-1986
	0.231	0.235	0.249	0.288

TABLE B.1 USNA SHORT-RUN MARGINAL COST CALCULATIONS CONTINUED.

STEP 1: Multiply the total variable costs for the particular fiscal year by the corresponding class percentage of the brigade.

FY-1989 0.231 X 63294023 = 14620919.31

FY-1988 0.235 X 64252220 = 15099271.7

FY-1987 0.249 X 59740493 = 14875382.76

FY-1986 0.288 X 58895464 = 16961893.63

STEP 2: Add the prorated costs = 61557467.4

STEP 3: Divide the total by the number of graduates: 1,082

$$\frac{61557467.4}{1082} = 56892.298$$

SHORT-RUN MARGINAL COST PER GRADUATE: $56,892

TABLE B.2 USNA LONG-RUN MARGINAL COST CALCULATIONS

Item	FY-1989		FY-1988		FY-1987		FY-1986	
	F	V	F	V	F	V	F	V
1.		32718368		30492350		24824000		21861570
2.	858871		908838		570000		680081	
3.		3052673		2850582		2310776		2250016
4.								
5.	53111	22029335	57958	23990956	51421	21285135	49953	20677461
6.	3286563	411372	3254314	551553	3159947	395509	3103154	388401
7.		2635394		2703820		2268784		2081989
8.		5928445		5894007		5691315		6249855
9.	1602471		1068095		1382935		1150233	
10.		2703584		2587169		3185792		2320002
11.		35094969		34610260		33479464		33455586
12.	4503765		2901128		5976740		5372678	
13.	1131628		1899947		1960420		1829019	
14.								
15.								
16.		1090948		885799		928950		885817
17.	2154041		3065007		2157158		1785546	
18.	277959		704640		549704		479952	
19.	1077716		1394566		1564675		1379988	
20.		6318873		5130946		5845174		5971497
21.	2989576		2431092		3276589		3254127	
22.	1412555		1320532		1272105		1166355	
23.	22808777		16160855		14070945		13929354	
24.	1674747		1248269		1471986		1415852	
25.	1171367	594611	1148499	477019	1139687	578521	1041841	528852
26.	757910		1298824		1573653		1287371	
27.	2413621	188366	1915516	149485	1841124	143680	1734652	135371
28.								
29.	1875105		1862952		1574117		1548148	
30.	3572629		3463188		2421934		2234602	
31.	841022	4477833	756089	4025652	652172	3472366	627089	3338814
32.					434702		422041	
33.	243258		474418		445053		427936	
34.	197820		176114		167530		158686	
35.	1044031		954273		906671		873650	
36.	1206711		1230677		893943		882533	
37.								
38.								
TOTAL VC	116143658		112830524		102606609		98975462	

Percent of Brigade:	FY-1989	FY-1988	FY-1987	FY-1986
	0.231	0.235	0.249	0.288

TABLE B.2 USNA LONG-RUN MARGINAL COST CALCULATIONS CONTINUED.

STEP 1: Multiply the long-run total variable costs for the particular fiscal year by the corresponding class percentage of the brigade.

FY-1989 0.231 X 116143658 = 26829185

FY-1988 0.235 X 112830524 = 26515173

FY-1987 0.249 X 102606609 = 25549046

FY-1986 0.288 X 98975462 = 28504933

STEP 2: Add the prorated costs = 107398337

STEP 3: Divide the long-run total by the number of graduates: 800

$$\frac{107398337}{800} = 134247.921$$

LONG-RUN MARGINAL COST PER GRADUATE: $ 134,248

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